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ADDRESS OF THE RETIRING PRESIDENT OF THE
SOCIETY, IN AWARDING THE BRUCE MEDAL
TO SIR WILLIAM HUGGINS.*

BY OTTO VON GELDERN.

Another year in the history of the Astronomical Society of the Pacific has passed, and it becomes my pleasant duty, as your President, to review in some manner the aims and the accomplished work of the organization.

It is the object of the Society, and it has always been its object from the time of its founding, after the total eclipse of January, 1889, to foster astronomical science, not only among those who are professionally engaged in such a field of labor, but to awaken an interest for this, the Queen of all Sciences, in any one whose sole purpose in life is not the all-absorbing search after material welfare to the exclusion of everything else.

There can be no more fascinating study than that of the starry heavens; there is nothing around us that appeals so strongly to all the nobler sentiments of the human heart, to all the finer qualities of the human intellect, than a contemplation of the vastness of creation, the multiplicity of the population of space, and the overwhelming thought, What is there behind all this that seems forever destined to be shrouded in the deepest of mysteries? If there is ever a time when a man realizes his own smallness and insignificance it is when on a bright starry night he looks upward into the heavens and beholds the evidences of an endless creation. If this does not start within him an impression of the deepest awe, if it fails to touch his heart, and if it leaves his mind without

* The data for this address are from the Lick Observatory, the library of the Astronomical Society, and the Mechanics' Library.

that indescribable sense of man's dependence, he may indeed be pitied as an unfortunate, and as one who has not realized the ideals which the man of the twentieth century should cherish and foster.

The Astronomical Society attempts to reach such an ideal by awakening within any one an interest in the affairs of the heavens by a means somewhat different from the theologian, but nevertheless with a purpose fully as definite,—and that is, to help make better men and better women by an appeal to their intellect and their nobler faculties.

Our means to spread astronomical knowledge are not only these periodical lectures, but also the publications issued from time to time; the very excellent library; the summer visits to the Lick Observatory, and thereby the occasional touch with the men who devote their lives to this absorbing science.

Another means to help our members in attaining a knowledge of astronomical principles and astronomical methods of work has recently been added to those already mentioned, and I am very glad to take this opportunity of announcing to you that Professor A. O. LEUSCHNER, the head of the Berkeley Astronomical Department of the University of California, will offer exceptional opportunities to our members during the coming Summer Session of the University, for the purpose of giving the amateur astronomers the advantage of acquiring skill in the various modes of observation. He desires me to state to you the following, which I quote from his letter to me:—

“There will be two courses offered by myself during the Summer Session, one of which will largely consist of practical observing with the many fine instruments now available at the observatory. It is my intention to form groups of such persons as may wish to avail themselves of the opportunities extended, and to enable each group to gain experience in one or more fields of observation. For example, some might be particularly interested in variable stars, others in spectroscopy, others in solar observations, others in planets, others in celestial photography, and others in various other observations with the transit instrument, sextant, or equatorials.”

Here is certainly a rare chance for our enthusiastic members to gain a practical knowledge in astronomy, which would be impossible without appliances and without instruments. I think that Professor LEUSCHNER would be interested to hear from any one who may desire to learn the necessary

details under which enrollment for this instruction is made possible.

With this short reference to the work of the Society, I, as your retiring President, congratulate you upon what has been accomplished, and hope that the future may be as bright as I would predict it. There is a field of usefulness before it, and we as members and interested individuals should never lose sight of the ultimate aim and the good mission which the Society has been created to fulfill.

With these heartfelt wishes I retire from my office, to leave it in hands abler than mine. Before doing so, however, there remains another duty to be performed, and I shall ask your indulgence for a short time to allow me to make a few remarks on the accomplished work of one of the great masters of the science that our Society fosters.

The Bruce Gold Medal of the Astronomical Society of the Pacific, founded by the late Miss CATHERINE WOLFE BRUCE, of New York, has been bestowed for the fifth time by the Board of Directors in conformity with the statutes governing the bestowal of this medal.

Those astronomers to whom it has been awarded previously are: SIMON NEWCOMB, of Washington, in 1898;

ARTHUR AUWERS, of Berlin, Germany, in 1899; .

DAVID GILL, of Cape of Good Hope Observatory, in 1900;

G. V. SCHIAPARELLI, of Milan, Italy, in 1902.

This time the choice has fallen upon one of the best known of English astrophysicists, one who has probably done more in his particular field of research than any other astronomer, who may be considered as a pioneer in a field that has opened up so many new directions of investigation, leading to results constantly tending to broaden the knowledge and with it the intellectual horizon of man. I refer to the eminent scientist, Sir WILLIAM HUGGINS.

It becomes my pleasant duty to-night to announce to you the unanimous choice of this great man for the honors that lie within our power to bestow.

It is customary that in making a report like this to you a sketch of the life and the work of the medalist be added. Life-histories of eminent men written for purposes of this kind can at best but contain mere references to their labors and prominent achievements, and if in taking a cursory glance

at the results accomplished by Sir WILLIAM HUGGINS in astrophysical science I should omit to mention even some of the most epoch-making discoveries, you will remember that in this particular case there are so many of them that a brief mention of what his labors have led to is all that can be attempted within the frame of an address like this.

WILLIAM HUGGINS was born in London, February 7, 1824. While his early education was received in the City of London School, it is very probable that his mind must have been awakened at a very early age to the realization of scientific fact, so that with his approaching manhood he had a practical knowledge of physical science. Study in microscopy upon animal and vegetable physiology had occupied his time to a considerable extent, and we hear of his becoming a member of the Microscopic Society in 1852.

But astronomy claimed his attention and became his chief pursuit, for in 1856 a private observatory for his studies was completed at Upper Tulse Hill, where he has constantly devoted himself to scientific investigations. At first they were probably confined to the measurements of the positions of celestial bodies, which was the principal work of the astronomer at that time.

.Original minds with original thoughts are not likely to follow any prescribed course in whatever pursuit they may be engaged, and so in this case. The master mind must have conceived at once the great possibilities offered to astronomy by the discoveries and researches of KIRCHHOFF and BUNSEN, and when it was realized that spectrum analysis could be applied to the heavenly bodies, that they could be made to speak their own language, or write their own autographs, as it were, then astrophysical science was born, and disclosed an endless expanse of almost virgin soil, from which the human mind has harvested results as unique as they are marvelous.

This was the field of Sir WILLIAM HUGGINS, in which he has labored with ever-increasing success from the year 1862 until the present time. What he has accomplished in this period of over forty years has been the subject of numerous sketches and articles that have appeared from time to time in the scientific journals of the day.

In an address before the British Association our medalist makes this statement:—

"In 1866 I gave before this Association an account of the first-fruits of the novel and unexpected advances in our knowledge of the celestial bodies which followed rapidly upon KIRCHHOFF's original work on the solar spectrum and the interpretation of its lines.

"Since that time a great harvest has been gathered in the same field by many reapers. Spectroscopic astronomy has become a distinct and acknowledged branch of the science, possessing a large literature of its own and observatories specially devoted to it. The more recent discovery of the gelatine dry-plate has given a further great impetus to this modern side of astronomy, and has opened a pathway into the unknown of which even an enthusiast thirty years ago would scarcely have dared to dream.

"In no science, perhaps, does the sober statement of the results which have been achieved appeal so strongly to the imagination and make so evident the almost boundless powers of the mind of man. By means of its light alone to analyze the chemical nature of a far-distant body; to be able to reason about its present state in relation to the past and future; to measure within an English mile or less per second the otherwise invisible motion which it may have towards us or from us; to do more, to make even that which is darkness to our eyes light, and from vibrations which our organs of sight are powerless to perceive to evolve a revelation in which we see mirrored some of the stages through which the stars may pass in their slow evolutionary progress,—surely the record of such achievements, however poor the form of words in which they may be described, is worthy to be regarded as the scientific epic of the present century."

The first researches were made with Professor W. A. MILLER, of Kings College, a chemist of note, who had made a practical application of spectrum analysis for a period of fifteen years. Their results were incorporated in the Report on the Spectra of Stars, sent to the Royal Society in 1863.

We know that starlight in passing through spectroscopic apparatus is severed into its constituent parts. The light is spread out into a band showing the usual prismatic colors. This band is crossed by lines and the spectroscopic problem is to read their meaning. Dark lines indicate to the spectroscopist that the light comes from an incandescent body, but has passed through cooler media,—that is, in its transmission some of it has been absorbed. Bright lines are evidences that the regions from which they hail are hotter than those below them, and an inspection of the star's spectrum may furnish us with valuable information regarding the physical condition of its atmosphere. Furthermore, the exact position of the spectral lines, and the method of measuring them, give a

clew to the existing chemical composition of the origin of the light.

The spectra of many stars had been compared with those of several terrestrial elements, and it was found that they are hot bodies, similarly constituted to our Sun, and containing many of the substances found on the Earth. The spectra of the planets *Venus*, *Mars*, *Jupiter*, and *Saturn* had also been observed, and the results of these observations were made public in 1864. It is stated that the light from the planet *Uranus* was found too faint to be satisfactory for spectroscopic analysis; but an improved telescope in 1871 resulted in certain determinations showing its spectrum to be continuous, so far as the feebleness of its light permitted it to be traced.

While FRAUNHOFER, LAMONT, and DONATI had examined star spectra before, it must be remembered that the work of HUGGINS lay in an entirely different direction. As stated in an article published in *Nature*, by H. KAYSER, in 1891, it was not simply the idea to see lines in the spectra of stars, but their chemical origin had to be determined; and therefore the light-gathering objective prism could no longer be used, but after the method of KIRCHHOFF and BUNSEN a slit and comparison-prisms were employed. Finding this to weaken the spectrum to a great extent, and in order to broaden the point-like image of the star, his resourceful mind, ever ready to surmount difficulties, introduced the cylindrical lens, made for him by BROWNING.

In undertaking comparisons of spectra it soon developed that the data for such purposes were very insufficient, and HUGGINS undertook the labor of recording the position-lines of a great many elements. This work was of immediate value and proved a great success. Referring to that time, he states, in "The New Astronomy":—*

"The observatory became a meeting-place where terrestrial chemistry was brought into direct touch with celestial chemistry. The characteristic light-rays from earthly hydrogen shone side by side with the corresponding radiations from starry hydrogen, or else fell upon the dark lines due to the absorption of the hydrogen in *Sirius* or in *Vega*. Iron from our mines was line matched, light for dark, with stellar iron from opposite parts of the celestial sphere. Sodium, which upon the Earth is always present with us, was found to be widely diffused through the celestial spaces."

* June number of the *Nineteenth Century*, 1897.

He refers to the time as one of great expectation, for nearly every observation revealed a new fact, and a new discovery was made nearly every night. "And yet, notwithstanding," he continues, "we had to record that the inquiry in which we had been engaged has been more than usually toilsome; indeed, it has demanded a sacrifice of time very great when compared with the amount of information which we have been able to obtain."

As the field broadened the problems multiplied; they crowded themselves upon this original investigator, and while the first problem may have been solely this: What are those shining points of light upon the celestial dome?—there soon suggested itself a second one to his fertile brain, which, like a question whispered to him from the depths of space, asked: Whence came they?

In the year 1864 he began his original researches in a hitherto unexplored region,—that of the nebulae. To this day there remains associated in his memory the profound awe which he felt on looking for the first time at that which the eye of man had never seen, and which even the scientific imagination could not foreshow.

The nature of these mysterious bodies was yet unknown; the view that they were parts of a fiery mist out of which the heavens had been slowly fashioned began to yield, based upon more recent telescopic investigations, to the opinion that all nebulae may be capable of resolution into stars. In the "New Astronomy," already referred to, HUGGINS states:—

"According to this view, nebulae would have to be regarded not as early stages of an evolutionary progress, but rather as stellar galaxies already formed, external to our system,—cosmical sand-heaps, too remote to be separated into their component stars."

It remained a question for a long time whether or not the nebulae could be resolved into stars if a sufficiently powerful telescope could be brought to bear upon them.

The result of HUGGINS's investigations revealed a new scientific fact, and his spectroscopic analysis of the nebular light led to one of the greatest triumphs in astrophysics,—that is, that this phenomenon is not the result of crowding together separate and innumerable stars, but that it is accounted for by the presence of a mass of incandescent gas.

It was on the evening of the 29th of August, 1864, that HUGGINS directed his telescope for the first time to a planetary nebula in *Draco*. In speaking of this memorable event, he says: "Picture to yourself to some extent the feeling of excited suspense, mingled with a degree of awe, with which after a few moments of hesitation I put my eye to the spectroscope." It seemed to him as though he were about to gaze into Nature's secret place of creation.

He looked into the spectroscope and saw—not the expected spectrum, no! Only a single bright line! At first he suspected some displacement of the prism, and that he was looking at the reflection of the illuminated slit from one of its faces. But according to his own description, and in his own words, the true interpretation flashed upon him after a moment's thought. The light of the nebula was monochromatic, and so, unlike any other light as yet subjected to prismatic examination, could not be extended out to form a complete spectrum. After passing through the two prisms it remained concentrated into a single bright line, having a width corresponding to the width of the slit, and occupying in the instrument a position at that part of the spectrum to which its light belongs in refrangibility. A little closer looking showed two other bright lines on the side towards the blue, all the three lines being separated by intervals relatively dark.

He proclaimed:—

"The riddle of the nebulae was solved. The answer which had come to us in the light itself read: Not an aggregation of stars, but a luminous gas. Stars after the order of our Sun, and of the brighter stars, would give a different spectrum; the light of this nebula had clearly been emitted by a luminous gas."

Continued observations led to the conviction of the very great probability of an evolution in mighty space of starry creations going on from an unfathomable past into an equally unfathomable future. This master mind had grasped the birth of the stars; his keenness of intellect, quick to discern, as rapidly to combine, had deduced from the very signals of the stellar universe the genesis of its atomic life. It is when we ponder over such mighty results that we are overwhelmed with the capabilities of the human intellect. HUGGINS gives us his conclusions in the following words:—

"A time surely existed when the matter now condensed into the Sun and planets filled the whole space occupied by the solar system, in the condition of gas, which then appeared as a glowing nebula, after the order, it may be, of some existing in the heavens. There remained no room for doubt that the nebulae, which our telescopes reveal to us, are the early stages of long processions of cosmical events, which correspond broadly to those required by the nebular hypothesis in one or other of its forms."

Another important event in astrophysics was marked by his observations on a new star in *Corona Borealis*, to which his attention had been called by JOHN BIRMINGHAM on May 18, 1866. HUGGINS viewed the spectrum of this star on this evening, after it had already fallen in brightness below the third magnitude, and obtained a result up to that time unprecedented. The spectrum was that of the solar order, with its numberless dark lines, upon which appeared a few very bright lines. There was little doubt in his mind that at least two of these lines belonged to hydrogen. It led him to believe that an unusual brilliancy of these lines was due to a gas of higher temperature than that of the star's photosphere, and that suggested to him a cosmic catastrophe, a sudden and vast convulsion which had taken place in a star that from emitting but faint light had blazed up to one of second magnitude, falling again in brightness within the short period of twelve days to one of the eighth.

Volcanic forces or the disturbing approach or partial collision of another dark star may have been the cause of the sudden outburst. HUGGINS says: "The essential character of the explanation lay in the suggestion of a possible chemical combination of some of the escaping highly heated gases from within, when cooled by the sudden expansion which might give rise to an outburst of flame at once very brilliant and of very short duration."

In these three cases, taken from the early labors of our medalist, we have covered three periods of cosmic life. If the gaseous nebula may represent the cradle or birth of a sun, a world, or a system, the work upon the spectra of the stars led to a new knowledge of their chemical nature and relative physical conditions, and may appeal to us as exhibiting the various activities of existing individual cosmic life; while the last phenomenon referred to in the sudden brightness of an

unknown member of the universe may represent to us its sudden destruction or tragic death.

But within these three stages of cosmic struggle there lay an enormous field of operation for this fertile mind, which was ever on the alert for new signals from the heavenly hosts.

The spectra of comets engaged his attention, and he found frequent opportunities to observe them. The faint comets did not lead to any very definite conclusions, but observations made on a bright wanderer in June, 1868, resulted in showing that the three bright bands, or flutings, of the spectrum agreed in position with three similar flutings in the brightest part of the spectrum of carbon. Very ingenious modes of comparison confirmed his expectation, and referring to the method and its results he states: "The comet, though subtle as Sphinx, had at last yielded up its secret. The principal part of its light was emitted by luminous vapor of carbon."

In 1881 an opportunity was offered for the first time to observe a bright comet by the spectroscope, fortified with suitable photographic plates, and this made it possible to extend the examination of its light into the invisible region of the spectrum at the blue end. The photograph brought to light a new fact; it led to the knowledge that nitrogen, as well as carbon and hydrogen, exists in comets.

Numerous systematic observations and original researches were made in his chosen special field of labor, all fruitful issues and events in the rapidly developing science of astrophysics. Fixed stars, nebulae, comets, and possible new stars were compelled to yield their secrets to him. He devoted some attention to spectroscopic observation of the Sun, and also to the effects of sun-spots in their modification of the spectrum, and devised a method for determining the chemical constitution and the shape of the solar protuberances.

He sought for an explanation of the mysterious solar corona, to which he referred in his Bakerian Lecture for 1885, and in his Presidential Address before the British Association in 1891, and again in a short discussion of an explanation suggested by SCHEINER in 1900, in which he says that the matter of the corona is still open to questions of interest, and must be left for new information that may reasonably be expected from the observation of future eclipses.

The photography of star spectra occupied his time from an early period, for he attempted to obtain such spectra as long ago as 1864; but it was only after the dry-plate process became a reality that he successfully applied this art to the production of spectral images of celestial bodies, which led to many important and interesting discoveries. A book has been published by Sir WILLIAM and Lady HUGGINS (Lady HUGGINS was a former Miss MARGARET MURRAY, of Dublin, whom he married in 1875, and who became his acknowledged principal assistant and collaborator in his researches), in which the progress of photography of stellar spectra is given to the scientific world under the name of "Atlas of Representative Stellar Spectra," a magnificent volume, issued in 1899, with numerous illustrations and artistic chapter initials, by the talented Lady HUGGINS, which may give one an idea of the enormous and painstaking labor bestowed upon this most interesting and far-reaching feature of stellar spectroscopy; it has, indeed, been compared to a dictionary, for with a little stretch of the imagination one may call it "A Handbook of the Language of the Stars."

There remains a special subject in stellar spectroscopy not yet mentioned, but one that is so well known that I need hardly refer to it here, and that is the measurement of the motions of the stars in the line of sight. It is this work which has been taken up at the Lick Observatory, and in which Director CAMPBELL has gained such well-deserved recognition, and through whom this observatory (in the words of Professor NEWCOMB) has gained at once a position of pre-eminence, which it maintains to the present time.

Dr. HUGGINS, as early as 1868, presented to the Royal Society some observations on a small change of refrangibility in a line in the spectrum of *Sirius* as compared with a line of hydrogen. It was known that changes in the position of the lines of the spectrum might be used as an indicator and scale of the radial velocity of the object from which the light emanated, on the principle, suggested by DOPPLER sixty years ago, on which a sound becomes sharper or flatter accordingly as the ear and the sound-producing object approach or recede. This principle applied to the spectrum indicates an approach of the star if the lines are displaced toward the violet end,

and a recession if this shift be toward the red end, providing that the displacement be not caused by pressure. The Earth's motion being known, the final result is the velocity of the star in the line of sight. Referring to his attempts to overcome numerous difficulties that presented themselves in this work, he says:—

“At last, in 1868, I felt able to announce in a paper, printed in the Transactions of the Royal Society for that year, the foundation of this method of research, which, transcending the wildest dreams of an earlier time, enables the astronomer to measure off directly in terrestrial units the invisible motions in the line of sight of the heavenly bodies.”

This method opened up a prolific field for spectroscopists, of whom a number have become very prominent. Improved methods of photography made it possible for Professor VOGEL to determine the motions in the line of sight of over fifty stars, with an accuracy of about an English mile a second. Other votaries, among them our lamented KEELER, have applied the method to a determination of the rotation of the Sun, of *Saturn* and his rings, and of *Jupiter*.

In the “New Astronomy” HUGGINS proposes a method of separating double stars too close to be individually visible. PICKERING and VOGEL have independently discovered by this means an entirely new class of double stars. In the publication above referred to he states that “it would be scarcely possible, without the appearance of great exaggeration, to attempt to sketch out, even in broad outline, the many glorious achievements which doubtless lie before this method of research in the immediate future.”

I think this statement could be applied with equal force to all the different lines of research followed by him, every one of which has opened an avenue of approach to one of the richest mines of scientific labor. The life work of this eminent octogenarian lies open before us, and it is one well done and conscientiously performed. It seems opportune that I should quote from a recent book by Professor SIMON NEWCOMB, one of the most interesting that it has been my privilege to read. I know of nothing that has charmed me more than the perusal of the “Reminiscences of an Astronomer.” And even fearing that in quoting from this book I may repeat in a measure what has already been dwelt upon,

I shall relate to you what our first medalist has to say about the last :—

“For the visiting astronomer scarcely a place in London has more attractions than the modest little observatory and dwelling-house on Upper Tulse Hill, in which Sir WILLIAM HUGGINS has done so much to develop the spectroscopy of the fixed stars. The owner of this charming place was a pioneer in the application of the spectroscope to the analysis of the light of the heavenly bodies, and after nearly forty years of work in this field is still pursuing his researches. The charm of sentiment is added to the cold atmosphere of science by the collaboration of Lady HUGGINS. Almost at the beginning of his work, HUGGINS, analyzing the light of the great nebula of *Orion*, showed that it must proceed from a mass of gas, and not from solid matter, thus making the greatest step possible in our knowledge of these objects. He was also the first to make actual measures of the motions of bright stars to or from our system by observing the wave-length of the rays of light which they absorbed. Quite recently an illustrated account of his observatory and its work has appeared in a splendid folio volume, in which the rigor of science is tempered with a gentle infusion of art which tempts even the non-scientific reader to linger over its pages.”

Sir WILLIAM HUGGINS is now eighty years old, and, as we have seen, has been an active scientist for nearly half a century. Many are the honors that have been heaped upon him. He became President of the Royal Astronomical Society in 1876; President of the British Association in 1891; President of the Royal Society in 1900. He has received a Royal medal, the Rumford medal, and the Copley medal from the Royal Society, and two medals from the Royal Astronomical Society.

Is it not remarkable from what small beginnings this great scientific growth took its origin?—a piece of glass made into the shape of a wedge or prism, refracting the Sun’s light, whose rainbow colors might be thrown upon a screen; a beautiful trifling toy that might delight a child,—and that is the spectroscope in its primitive form,—a simple glass, yet with an inherent power to wrest from the mighty universe its most mysterious secrets.

These are the seven colors recited by Sir WILLIAM himself in poetic form :—

“First the flaming red
Sprung vivid forth; the tawny orange next;
And next delicious yellow; by whose side
Fell the kind beams of all-refreshing green.

Then the pure blue, that swells autumnal skies,
Ethereal played; and then, of sadder hue,
Emerged the deepened indigo, as when
The heavy-skirted evening droops with frost;
While the last gleamings of refracted light
Died in the fainting violet away."

That these beautiful colors, which God himself placed within the heavens as a symbol of his good will to man, contained more than a poetic meaning, that within them lay a language from the heavens that needed but an inspired interpreter to reveal, has been amply demonstrated by the life's labor of our medalist, Sir WILLIAM HUGGINS.

And in his absence, Mr. Secretary, I shall charge you with the mission of sending the medal to Sir WILLIAM, with our best wishes that he may live to see more years in which to enjoy the fruits of his accomplished work so modestly and unselfishly given to the world.

If our imagination can create the spectrum of a man's life, may his be to the end one crossed by bright lines only.

March 26, 1904.

PHOTOGRAPHS OF BORRELLY'S COMET (1903 *c*).

BY SEBASTIAN ALBRECHT.

It is aimed in this paper to give a brief account of thirty-six negatives of Comet 1903 *c* (BORRELLY), obtained at Mount Hamilton between June 22d and August 18th, inclusive.*

Two distinct types of tails persist throughout the entire series of photographs. The principal tail is long and straight in its general direction, and in a large number of cases can be traced to the edge of the plate, a distance of ten degrees. It developed some very interesting forms, changing its aspect completely from day to day. Several more or less permanent features of the main tail deserve special mention. Its length was always considerable, and it was directed almost exactly away from the Sun. The mean deviation of the tail from the

* A more complete account, with tables of measures and descriptions of the negatives, is published in *L. O. Bulletin* No. 52, and in the *Astro-Physical Journal* March, 1904.